THE WEATHER AND CIRCULATION OF AUGUST 1958 [1]

A Month with an Unusual Temperature Reversal

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1. INTRODUCTION

Over North America the mean flow pattern during August 1958 (fig. 1) was characterized by pronounced blocking in the extreme north and by a planetary wave in relatively fast westerlies at middle latitudes consisting of a ridge in the western United States and a trough in the East. In contrast to July 1958 [3], these features of the westerly circulations were near their climatologically preferred locations for the month and hence closely resembled the normal map but with slightly greater amplitude. They were responsible for an unusually warm regime in the West, which completely reversed the pattern of the previous month. A July-August reversal of this magnitude has occurred only once before in the past 17 years.

2. GENERAL CIRCULATION

The blocking High over northern Canada and its deep companion depression across the pole accounted for the two largest departures from normal (+410 ft. and −500 ft., respectively) which appear on the mean chart for the month (fig. 1). These two features became established early in the month, moved but little throughout the period, and completely dominated the weather of the polar basin and adjacent land areas. The polar Low was particularly persistent and vigorous, with a departure from normal at one stage in excess of 700 ft. (5-day mean map for Aug. 16–20, fig. 5). However, although a pronounced depression existed at high latitudes, the circulation over the remainder of Europe and Asia was weak and flat.

The trough normally found in the western Pacific was weak and ill-defined, with the principal Pacific trough lying well to the east between 150° and 160° W. This corresponded roughly to its position during July [3] and illustrates the tendency of this regime to persist, even though the long-period climatological statistics indicate that troughs are not at all favored in this longitudinal band in midsummer [7]. Though the amplitude of this feature remained small, its center averaged 240 ft. below normal, and it maintained sufficient vigor to sustain the downstream ridge in western North America and effectively fill the northern portion of the west coast trough, leaving the latter effective only at lower latitudes and well offshore. This constitutes a significant change from July [3] when this depression, though similarly confined to southerly latitudes, was deeper and lay inshore along the California coast. As a result of this filling and retrogression, the cyclonically curved flow, which characterized the July pattern in the West, was replaced by anticyclonic streamlines in August which resulted in profound changes in temperature and precipitation anomalies.

As mentioned, eastern North America and the Atlantic were strongly influenced by blocking. Twin warm Highs appear on the monthly mean pattern (fig. 1), one over northern Canada and the other over southern Greenland. These are associated with depressed polar vortices in eastern Canada and Iceland and the maintenance of a broad band of strong westerlies across the Atlantic at temperate latitudes. The jet stream, as illustrated by figure 2, reached a maximum speed of 14 m. p. s. at 45° N., 50° W., or 4 m. p. s. higher than the normal at that point. This broad westerly wind stream and the deeper than normal trough along the east coast, combined to favor recurvature of tropical storms at sea followed by rapid motion across the Atlantic.

3. HARMONIC ANALYSIS OF THE MEAN MONTHLY CHART

In recent years increasing study has been given to the spectrum of amplitudes and energy of meridional motions on the scale of the general circulation. Graham [5], for example, studied the latitudinal variation of the 17,800-ft. contour of the 500-mb. surface and found that the sum of the first three harmonics adequately describes the normal map for January. He also found that the total of these components remained nearly stationary on daily 500-mb. charts during the month of January 1952. More recently, others [4, 6, 11] have dealt with energy spectra of the meridional component of the circulation. In general it has been found that two distinct wave number bands exist in the atmosphere, one incorporating waves one through four, and the other wave number five and above. The first class of waves is semi-permanent and may be associated with the fixed topographic features of the earth's surface, while the second is connected with the smaller migratory systems.

In order to study the amplitude spectrum of meridional flow for August 1958, a harmonic analysis of the 700-mb. flow pattern was prepared, following the procedure described in [10]. The results are shown in figure 3 in which amplitudes are plotted against wave number for the latitudes 75° N., 60° N., 45° N., and 30° N. The pre-

[1] See Charts I-XVII following p. 328 for analyzed climatological data for the month.

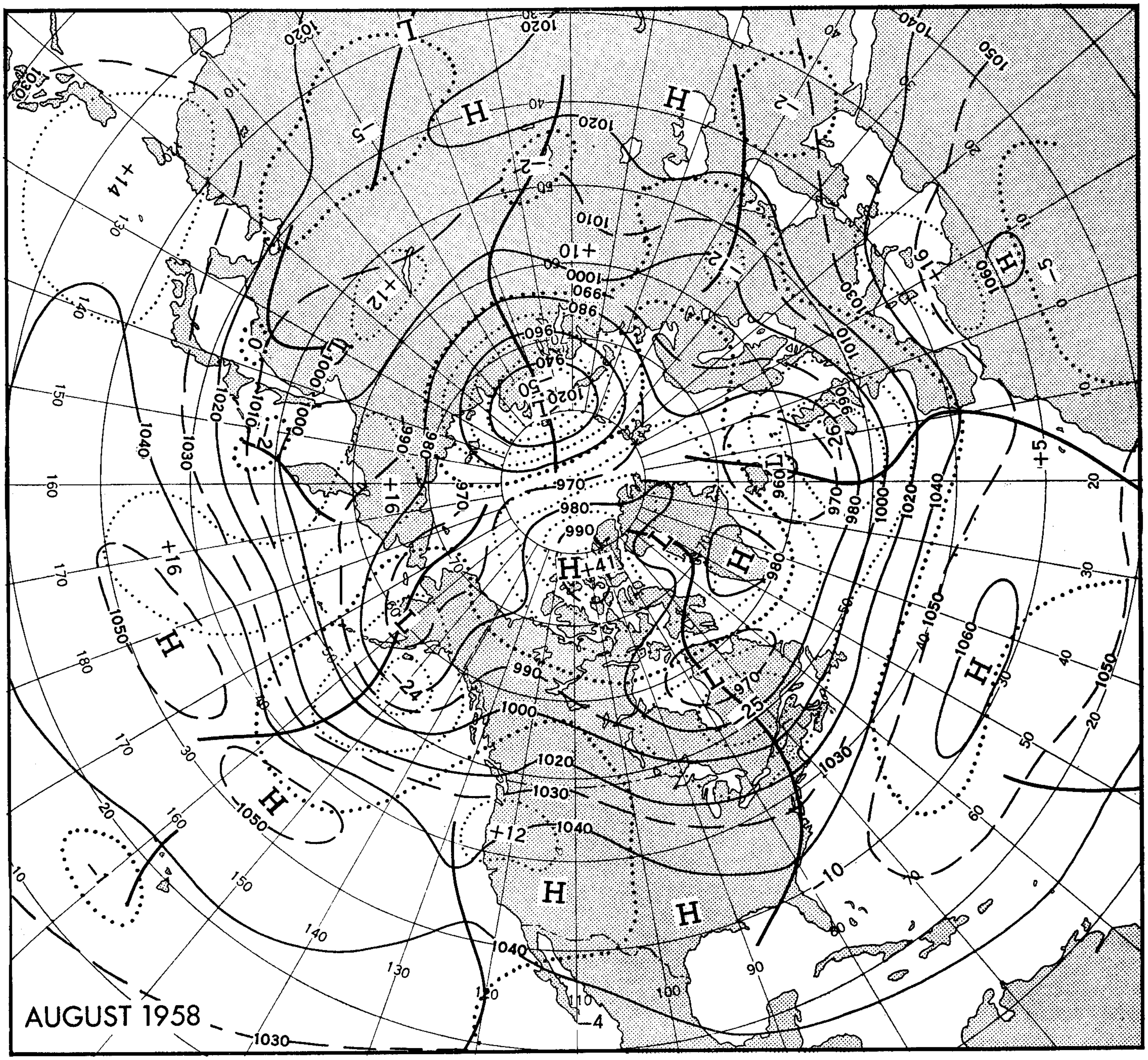


FIGURE 1.—Mean 700-mb. height contours (solid) and departures from normal (dotted) both in tens of feet with troughs indicated by heavy lines, for August 1958. The circulation pattern over North America included a ridge in the West and trough in the East. The trough along the west coast was weak and effective only at low latitudes.

eminence of the first harmonic at high latitudes is strikingly illustrated by the curve at 75° N. (and to a lesser extent by that for 60° N.). This reflects the existence of the two large anomaly centers on either side of the pole already described and indicates the degree of eccentricity introduced by such a circulation. The normal circulation for August similarly shows a maximum amplitude in wave one at 75° N. but only of about one-third the magnitude.

At 60° N. the maximum amplitude was still associated with the first harmonic, with a weak secondary peak beginning to appear in the fourth harmonic. This second maximum was also in evidence at 45° N. and 30° N. but displaced toward the higher wave numbers (dashed line). This characteristic dual maximum at temperate latitudes agrees roughly with the data of Eliassen [4] who found maximum amplitude at wave number one and again at wave number five, although his data were for a different level (500 mb.) and period (October 21 to November 30, 1950). Conspicuous in the graph for 30° N. was the very large amplitude accompanying the low wave numbers. However, interestingly enough, the normal also exhibits a similar distribution, except that the amplitude of the first harmonic is even larger, a surprising 167 ft. The phase angle is such in each instance that it is largely attributable

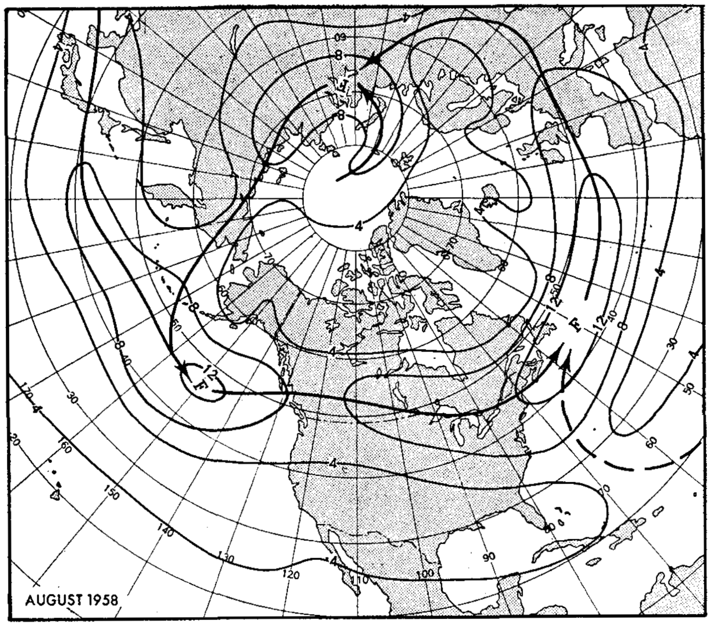


FIGURE 2.—Mean 700-mb. isotachs (in meters per second) for August 1958. Solid arrows indicate the position of the primary jet axis which roughly paralleled the northern border but dipped southward over the Atlantic because of blocking to the north.

to the Asiatic monsoon and illustrates the marked eccentricity which this phenomenon impresses on the low-latitude circulation in midsummer.

The first four harmonics accounted for 91 percent of the variability of the pattern for August 1958, and the addition of the next four increased this figure to over 99 percent. For the normal chart for August, the first four harmonics similarly contain most of the variance (97 percent), in agreement with the work of Graham [5], and only an additional three are needed to increase this to 99 percent. Thus, waves one through four strongly dominate both the pattern for the month and its normal. This highlights the semi-permanence of these long planetary waves as opposed to the random nature of the shorter transient waves. However, the former are just those components which are inadequately handled by simple numerical models, which confirms the necessity of a different approach to this problem, as recently emphasized by Burger [1]. A step in this direction was taken by the Joint Numerical Weather Prediction Unit at Suitland in an attempt to take into consideration the special behavior of these ultra-long waves [2, 12]. Also it was this consideration which led Namias [9] to incorporate the extraction of "latitudinal anomalies" as an integral part of his "basic current" model.

4. RETROGRESSION OF 5-DAY MEAN FEATURES

As is often the case, considerable variation about the monthly mean occurred, and one of the more interesting trends discernible on 5-day mean charts was a long-period retrogression. To illustrate this tendency, three 5-day mean maps centered one week apart were selected (fig. 4). In the initial state, represented by the chart for August

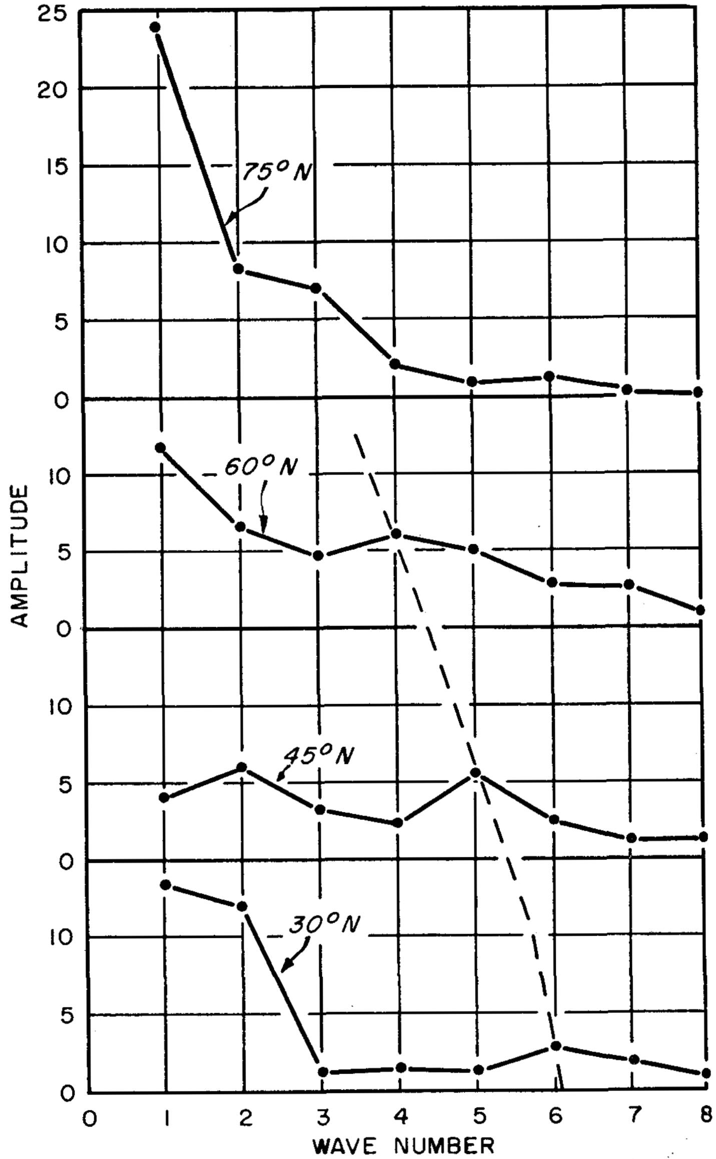


FIGURE 3.—Amplitude in tens of feet of the zonal harmonic wave components at 75° N., 60° N., 45° N., and 30° N. for the 700-mb. mean chart for August 1958 plotted against wave number. For wave number one the amplitude was a maximum at both high and low latitudes, the former reflecting the eccentricity of the polar vortex and the latter the eccentricity imposed by the Indian monsoon. A secondary peak appeared at 60° N. in the fourth harmonic which was displaced toward higher wave numbers.

7 to 11 (fig. 4A), a fast westerly flow characterized the circulation with two pronounced troughs in the Pacific and a third off the United States east coast. One week later (fig. 4B) the pattern in the Pacific underwent a major transformation. The deep trough off Japan filled abruptly, resulting in an extended wavelength between the eastern Pacific trough and its new upstream counterpart over eastern Asia. It adjusted to the new situation by retrograding to the position shown in figure 4B, leaving in its wake a cut-off and greatly weakened trough near the California coast. This was associated with a westward displacement of the ridge-trough structure over North

America. This retrogression of the east coast trough coincided with the period when tropical storm Becky was approaching recurvature and permitted that storm to recurve off the coast in approximate conformity with the normal track for August.

The Pacific trough continued its retrogression during the third week (fig. 4C), and once again the downstream features over North America followed suit. By this time the Canadian ridge was sufficiently far west to become realigned with the intensified maritime ridge in the eastern Pacific rather than with the High in the Plateau States as previously. As a result, the United States trough shifted all the way back to the Mississippi Valley, which led to the only outbreak of really cold air into the central portion of the country. At this time, the Atlantic circulation also reacted by reversing the tendency for eastward motion of the Atlantic ridge. In fact, comparison of the change in position and strength of the Atlantic anticyclone from figure 4B to figure 4C indicates a net westward displacement of some 10°. This sharp retrogression of both the United States trough and the Atlantic ridge was instrumental in influencing hurricane Daisy to recurve farther west than either of its predecessors.

It is noteworthy that, despite the overall retrogressive tendency described above, the trough in the eastern Atlantic succeeded in making eastward progress as far as the European coast (fig. 4C). However, the resultant overextended wavelength was subsequently adjusted by rapid discontinuous retrogression of this feature as well.

5. TROPICAL STORMS IN RELATION TO THE MEAN CIRCULATION

During August, three of the four storms which developed over the tropical Atlantic became hurricanes. Except for Ella, these fortunately remained at sea and recurved offshore, in rough accord with the mean circulation for the month (fig. 1). The first tropical storm, Becky, was detected near the Cape Verde Islands on August 10, though its exact position could not be established until a reconnaissance flight fixed the center about 20° east of San Juan on the 12th. From that point the storm continued moving westward at a rapid rate, averaging over 20 knots over its entire course prior to recurvature and at one time reaching a forward motion of 25 knots. As it came under the influence of the mean trough along the east coast it turned northward and recurved well offshore (Chart X). Becky never attained full maturity as a hurricane but remained fairly weak over most of its long trajectory.

On the other hand, Cleo, the second storm, which followed Becky by only two days, was already a severe hurricane when first explored by reconnaissance on August 14 when about 750 miles east of the Lesser Antilles. Although reports were insufficient to establish a definite track, it is probable that this storm had its origin in a tropical depression to the southeast of the Cape Verde Islands on the 11th. If this is the case, it progressed rather rapidly (about 21 m. p. h.) over the first portion of its journey, but deceleration must have begun near 45° W. prior to the reconnaissance penetration of the storm since thereafter it moved more slowly and shifted to a more north-northwesterly course (fig. 5).

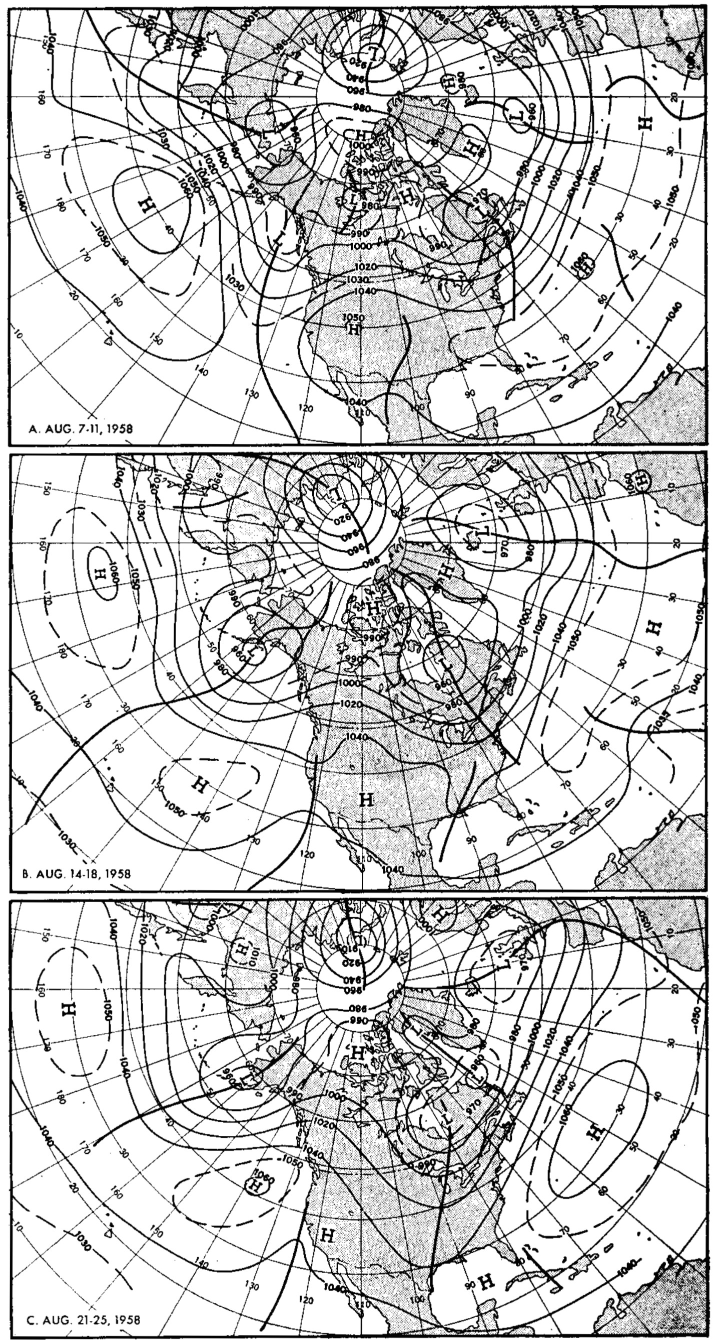


Figure 4.—Five-day mean 700-mb. charts (in tens of feet) for (A) August 7–11, (B) August 14–18, and (C) August 21–25, 1958. The filling of the deep mean trough in the western Pacific resulted in retrogression of the west coast trough the following week (B) and of the United States trough and Atlantic ridge the third week (C). After the first period the west coast trough was weak and confined mainly to low latitudes.

The key transformation, accompanying this shift in trajectory from that of Becky appears to have been the eastward motion of the Atlantic ridge and the splitting of

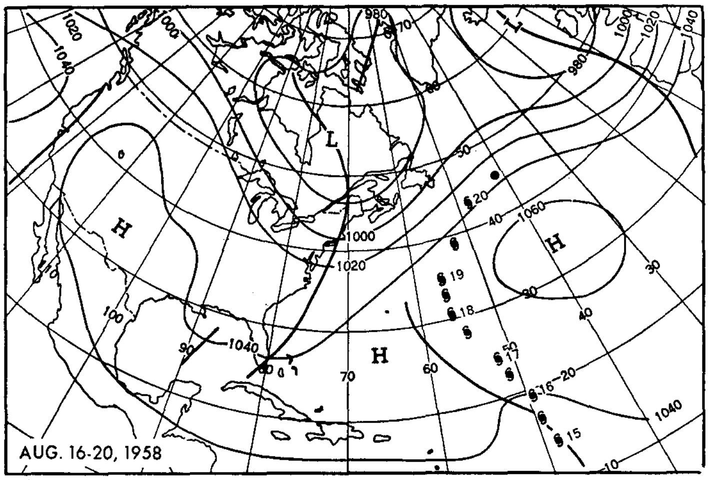


Figure 5.—Five-day mean 700-mb. chart (in tens of feet) for August 16–20, 1958, with track of hurricane Cleo superimposed. The Atlantic ridge moved sufficiently far east that Cleo was able to penetrate the subtropical High.

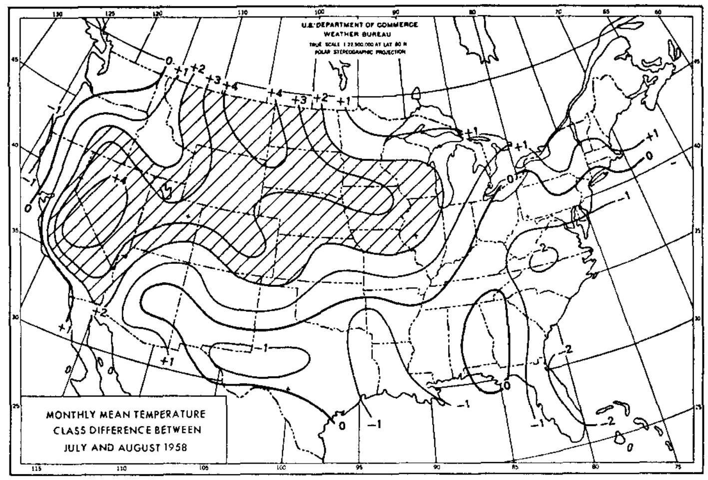


Figure 6.—The number of classes the anomaly of temperature changed from July to August 1958. A marked reversal in temperature took place over a broad area in the West and North Central Plains.

the subtropical high pressure cell (fig. 5). The retrogression, described earlier as affecting the Pacific and the United States, had not yet begun to influence the Atlantic. As a result the ridge succeeded in making eastward progress, though in the face of a lengthening wavelength. Subsequently (fig. 4C) this ridge did retrograde sharply, but it remained far enough east just long enough for Cleo to penetrate the subtropical high pressure belt. The evolution of this development is of some interest. On the 5-day mean map for August 7–11 (fig. 4A) the westernmost cell of the subtropical high pressure belt was the stronger. One week later, however (fig. 4B), the eastern center had grown at the expense of the western one, and two days later (fig. 5) it was definitely predominant. It is quite possible that the storm itself contributed to the anticyclogenesis and thus influenced its own steering pattern.

6. THE TEMPERATURE REVERSAL

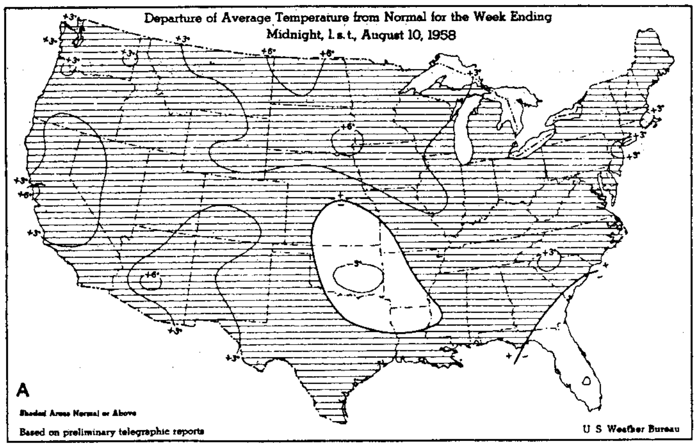
The outstanding aspect of the temperature pattern for this month was the pronounced reversal from July which took place over most of the western portion of the country. Ordinarily, the reverse is true and the transition from July to August has usually been characterized by marked stability of the temperature pattern. In fact, in a study based on the period 1942 through 1950 and later extended to 1957, Namias [8] found persistence to be higher between this pair of months than for any other pair during the year. In his paper, persistence was expressed in terms of the percentage of stations at which the temperature did not vary by more than one class (out of five). For the change from July to August this statistic turned out to be 80 percent, the maximum for the year. This August, however, only 59 percent of the stations fell within this interval. Since the chance expectance of this event is also 59 percent, no significant persistence occurred. During the past 17 years, only August 1947 had a lower persistence tendency, with 51 percent.

In August 1958, warming of two classes or more (cross hatched in fig. 6) encompassed an extensive area from the interior of California to Illinois, with maximum change (four classes) over Nevada and western Montana. The departure from normal of the monthly mean temperature rose 9.5° and 9.2° at Billings and Havre, Mont., respectively, and 9.1° at Winnemucca, Nev., to cite the three highest. These are unusually high figures and highlight the unusual nature of the change which occurred this month.

The key changes in circulation accompanying this reversal in pattern have already been described in section 2, namely, the strong ridging in the West which changed the flow from cyclonic in July to anticyclonic in August and relegated the west coast trough to a minor role offshore.

Temperatures along the Pacific coast continued well above normal for the fourth successive month. Record warmth for August was reported from several locations in Oregon and from Seattle, Wash. Tatoosh Island experienced the warmest August in at least 56 years, and record or near record temperatures were the rule at most California coastal locations. This prolonged period of warmth along the Pacific coast has constituted one of the most distinctive characteristics of the temperature regime so far this year and has been linked to abnormally warm ocean temperatures in previous articles of this series [3]. While a similar effect in all likelihood continued this month, the heat wave in the West can be adequately explained in terms of the large-scale ridging in the West, above normal sunshine, and southerly components of flow.

In general, temperatures in the rest of the country remained nearer normal, ranging slightly above normal over the Appalachians and eastward and slightly below normal over the States bordering the western Lakes and in



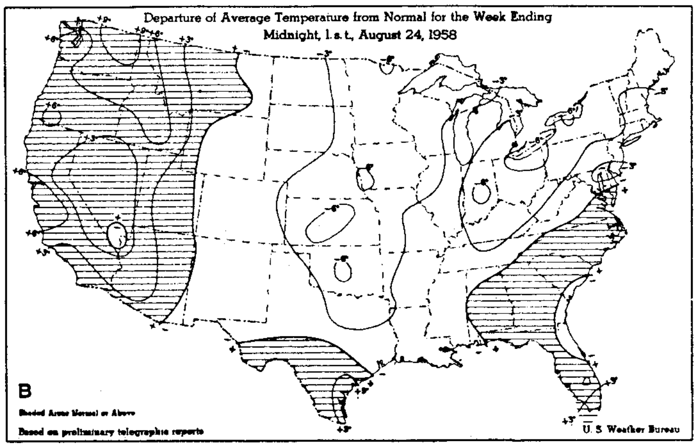


FIGURE 7.—Departure of average surface temperature from normal (° F.) for the weeks ending at midnight (A) August 10 and (B) August 24. The abnormal warmth which prevailed during the first period, especially over the Northern Plains, was followed two weeks later by an intense cold snap affecting central portions of the country.

the Ohio and Lower Mississippi Valleys. Departures from normal were small because a warm regime early in the month was largely cancelled in the mean by a marked outbreak of polar air in the eastern two-thirds of the country toward month end. Figure 7A was selected to represent the warm regime. During this week temperatures were unseasonably high nearly everywhere but, relative to normal, were warmest in the northern Great Plains and Southwest where temperatures ranged up to 6° above normal. Maximum temperatures in the northern Great Plains rose into the 100's on the 8th and 9th, and Bismarck, N. Dak. recorded 107° F., the highest there since 1949. For these States and for those bordering the Lakes, where June and July had been unusually cool, this was the first real taste of summer weather. The circulation for this period (fig. 4A) was characterized by broad westerly flow along the northern border with mainly anticyclonic curvature. However, it will be recalled from section 4 that the stage was about to be set for a large-scale retrogression of planetary waves on 5-day mean maps. This was accomplished by the week of August 18–24, and during this period (fig. 4C) the principal mean trough became entrenched over the Mississippi Valley, bringing

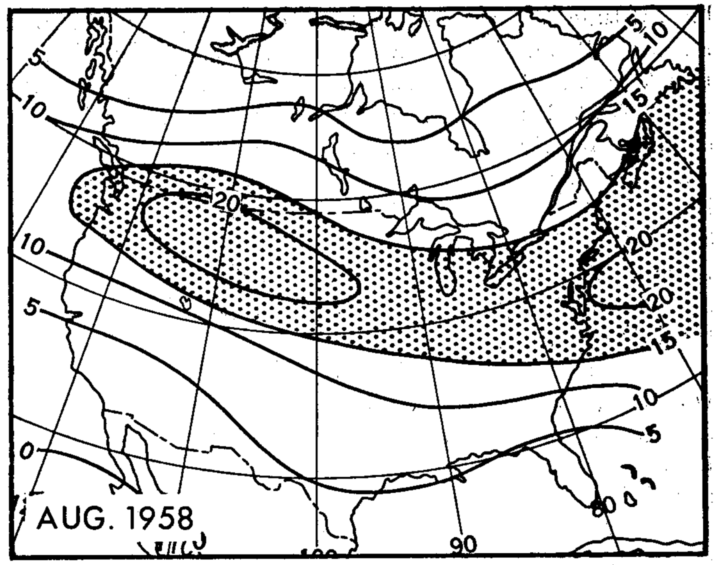


FIGURE 8.—Number of days in August 1958 with surface fronts of any type (within squares with sides approximately 500 miles). The band of maximum frontal activity extended from the Central Atlantic States west-northwestward.

an abrupt termination to the hot weather in the Midwest. The strongest and most widespread outbreak of cold air of the month was initiated at this time and penetrated to the Gulf of Mexico. Figure 7B depicts the thermal distribution which ensued. Temperatures dropped rapidly, and Madison, Wis. recorded 37° F. on the 25th, the lowest temperature reached there in August during the 80-year period of record. Near-freezing temperature occurred in the region of the western Lakes, and early season frost was reported in the higher elevations in the Black Hills of South Dakota. Thus, after only a brief period of summerlike weather in the Midwest, conditions more typical of fall were suddenly reintroduced.

7. PRECIPITATION

In general the precipitation for August, while not nearly as heavy as for June and July, was nevertheless adequate over most areas. However, the July pattern of heavy rains and flooding through the Ohio Valley and Central Plains continued to dominate early August. Flood stages maintained in a number of streams in Illinois and Indiana; some of these streams had been in flood since about mid-June. A record 30.0-ft. stage was reached at New London, Mo. as a result of rains in excess of 6 in. in the upper reaches of the Salt River. This exceeded the previous high reached in June 1928 by 1.2 ft. Thereafter, however, these excessive rains terminated as the ridge moved into the Midwest and brought warm drying winds to the area.

During this period, when the subtropical ridge was at its strongest across the Atlantic and the Southern States (fig. 4A), onshore winds and easterly wave activity brought tropical rains to the Gulf States. In fact, this type of activity was quite prominent during August, and a number of 5-day mean maps (figs. 4, 5) exhibit pieces of weak low-latitude troughs in the Gulf or along the Mexican border. These also served to furnish a supply of Gulf moisture so that frontal activity, which was fairly frequent in the East-Central States (fig. 8), succeeded in releasing substantial rainfall. In this manner a band of above normal precipitation for the month was produced, extending from Texas northeastward to the Central Atlantic States (Chart III–B). One of the heaviest of these frontal rains transpired in central and eastern Oklahoma on the 20th when 5 to 9 inches fell locally and caused considerable flood damage.

Frequent shower activity was widespread in the Southwest and, as a consequence, rainfall exceeded twice the normal over an extensive belt extending from California to southern Oregon (Chart III–B). This precipitation resulted from a moist tongue which curved anticyclonically around the western High and was sustained by Gulf moisture which was transported across Mexico by a broad current from the east-southeast.

During this period Blue Canyon, Calif. reported the greatest number of thunderstorms ever to occur in August; Winnemucca, Nev. experienced the wettest August of record; and heavy showers and even a few flash floods occurred over the southern Sierras and desert regions of California. On the other hand, Grand Junction, Colo., which lay in the dry tongue on the opposite side of the mean ridge, (fig. 1), experienced the driest August in the station record which dates back to 1892.

In the Northwest, which remained hot and tinder-dry for the entire month, a serious range and forest fire hazard developed. Scores of fires were reported in the mountains of Oregon with several reaching significant proportions before being brought under control. Also, lightning started many fires in the Sequoia National Forest and other brush and forest covered regions of California.

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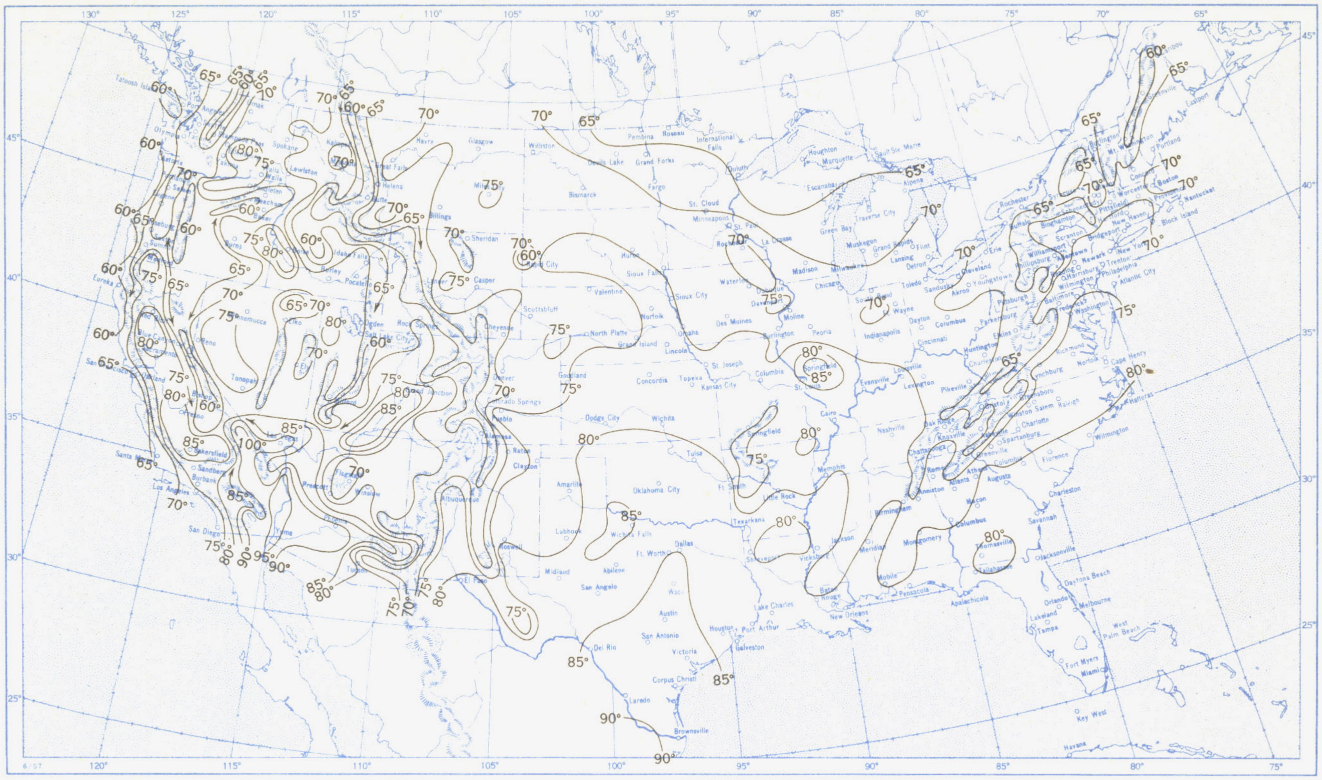
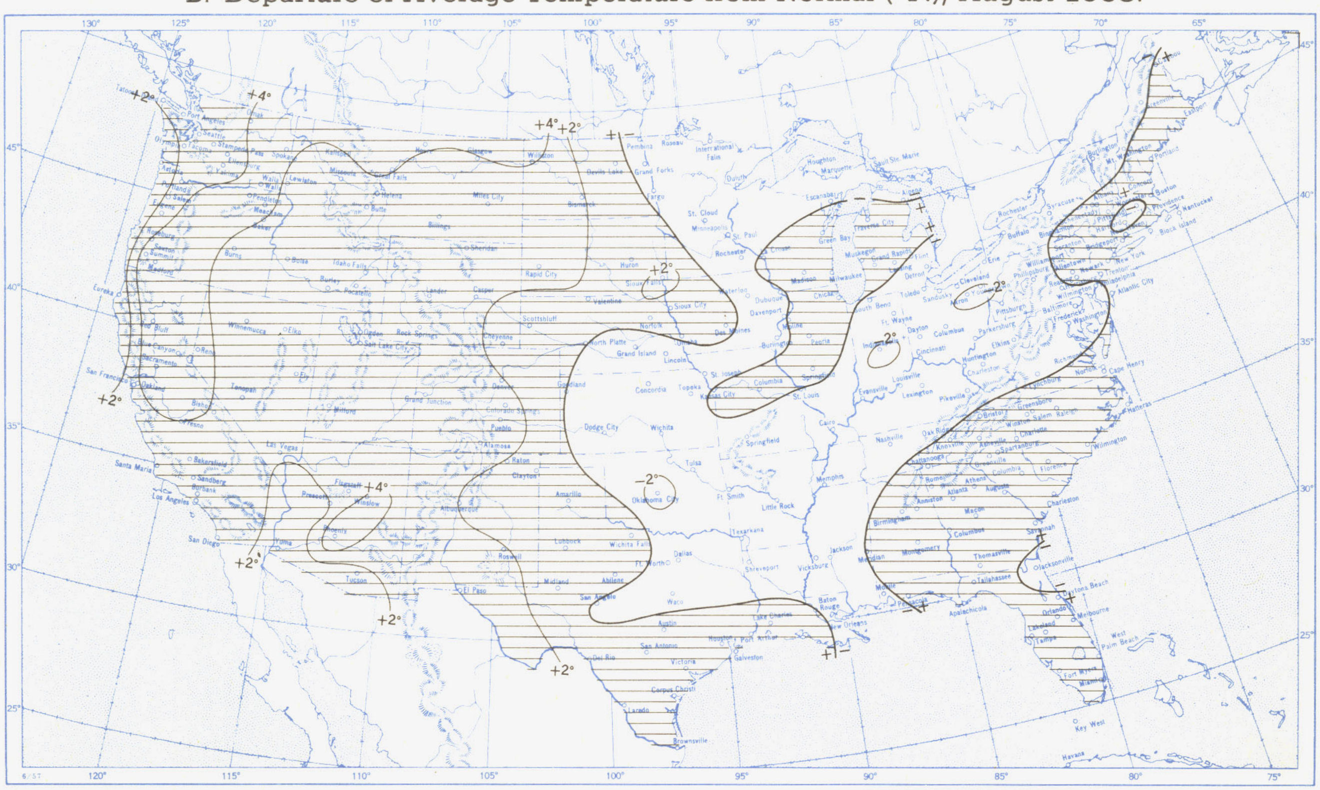
Chart I. A. Average Temperature (°F.) at Surface, August 1958.

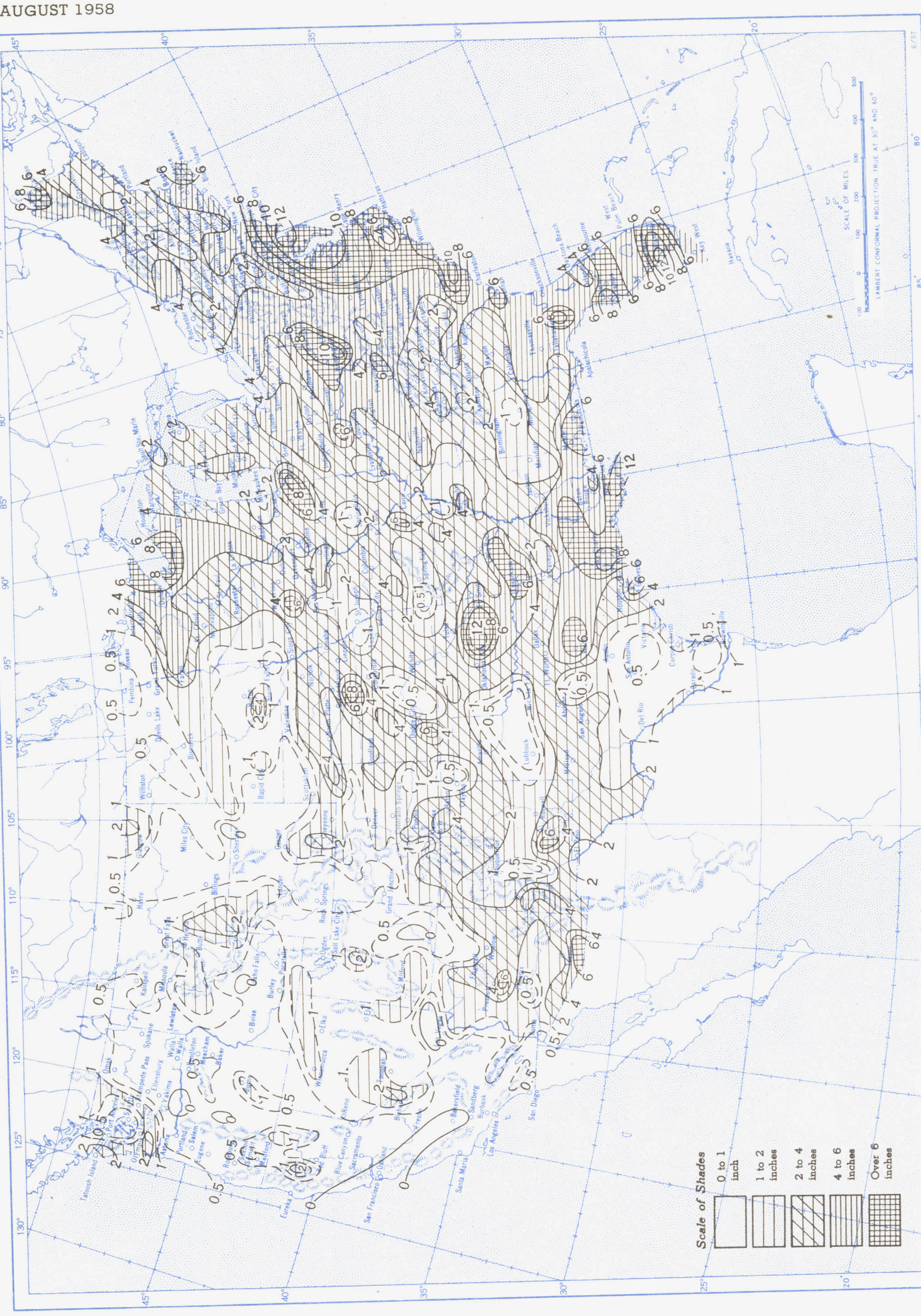


B. Departure of Average Temperature from Normal (°F.), August 1958.



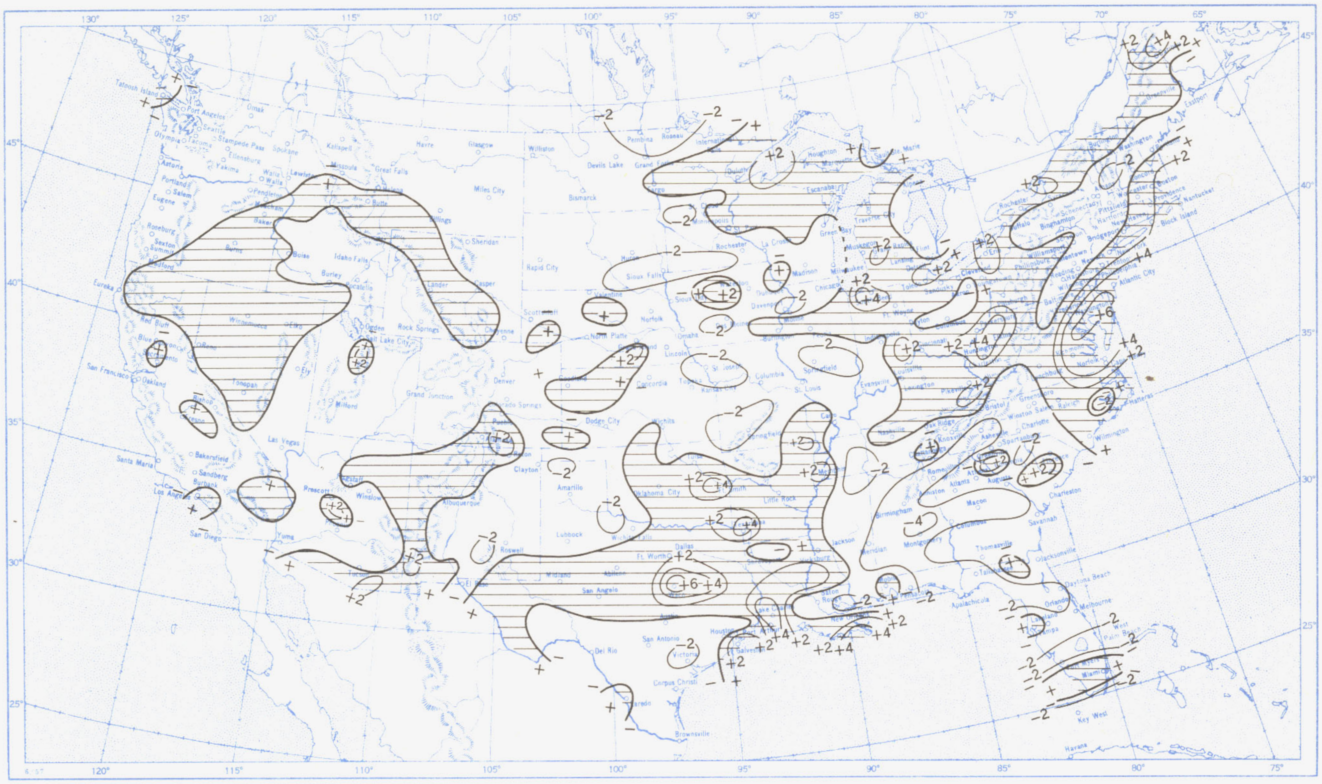
A. Based on reports from over 900 Weather Bureau and cooperative stations. The monthly average is half the sum of the monthly average maximum and monthly average minimum, which are the average of the daily maxima and daily minima, respectively.
B. Departures from normal are based on the 30-yr. normals (1921-50) for Weather Bureau stations and on means of 25 years or more (mostly 1931-55) for cooperative stations.

Chart II. Total Precipitation (Inches), August 1958.

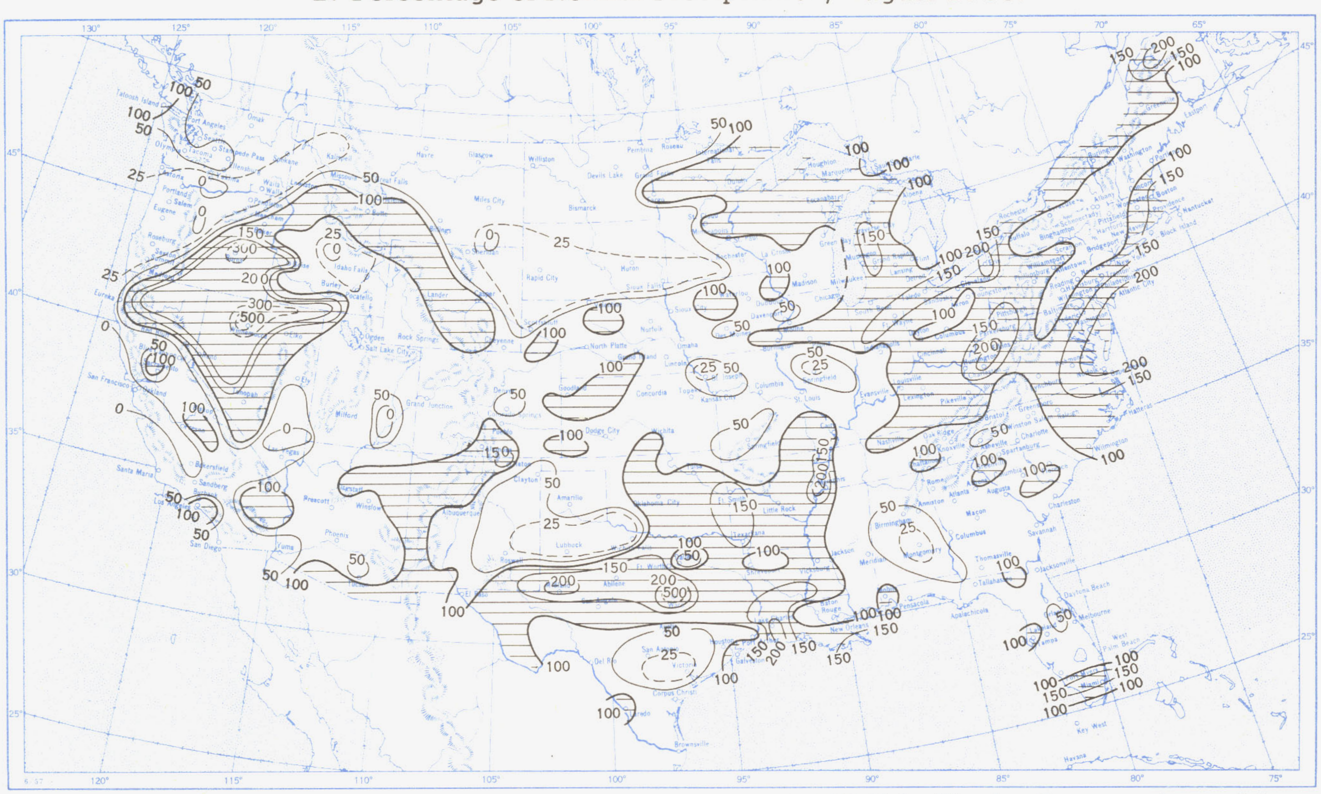


Based on daily precipitation records at about 800 Weather Bureau and cooperative stations.

Chart III. A. Departure of Precipitation from Normal (Inches), August 1958.

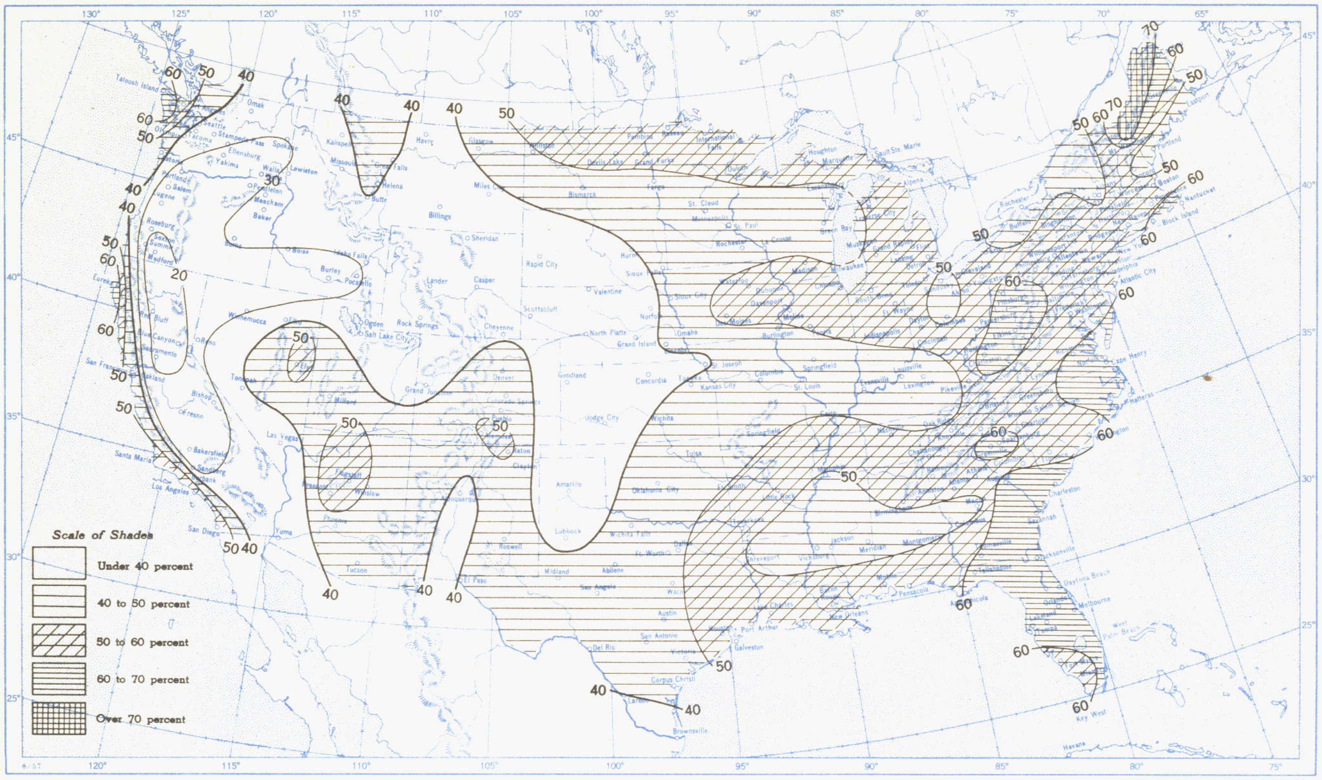


B. Percentage of Normal Precipitation, August 1958.

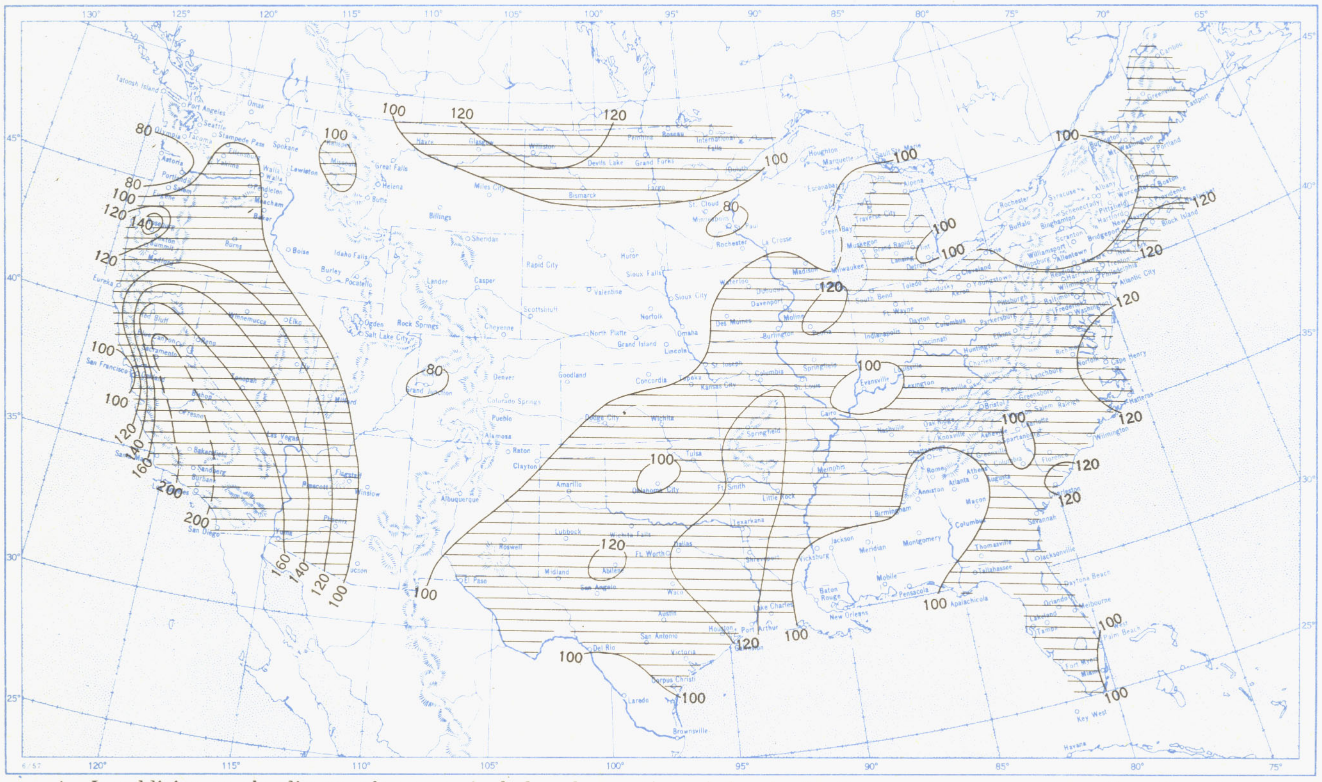


Normal monthly precipitation amounts are computed from the records for 1921-50 for Weather Bureau stations and from records of 25 years or more (mostly 1931-55) for cooperative stations.

Chart VI. A. Percentage of Sky Cover Between Sunrise and Sunset, August 1958.

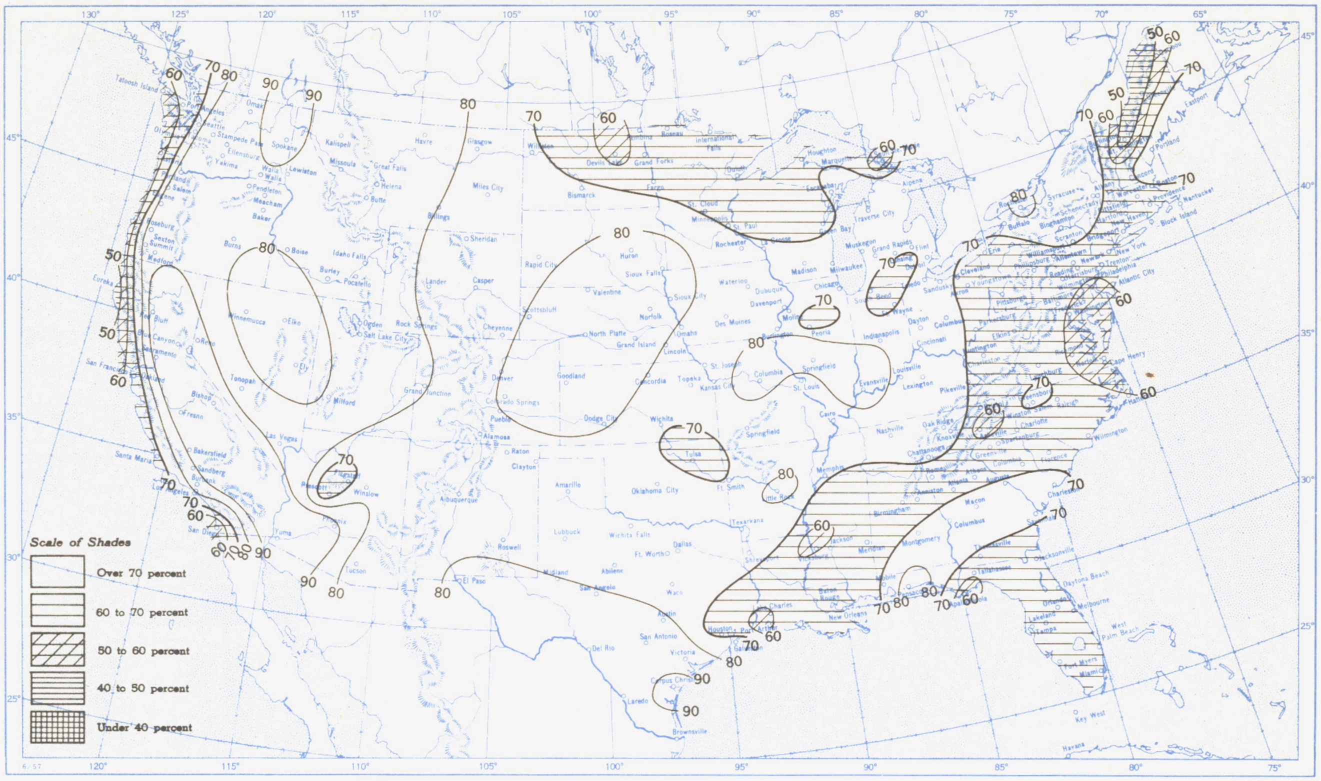


B. Percentage of Normal Sky Cover Between Sunrise and Sunset, August 1958.

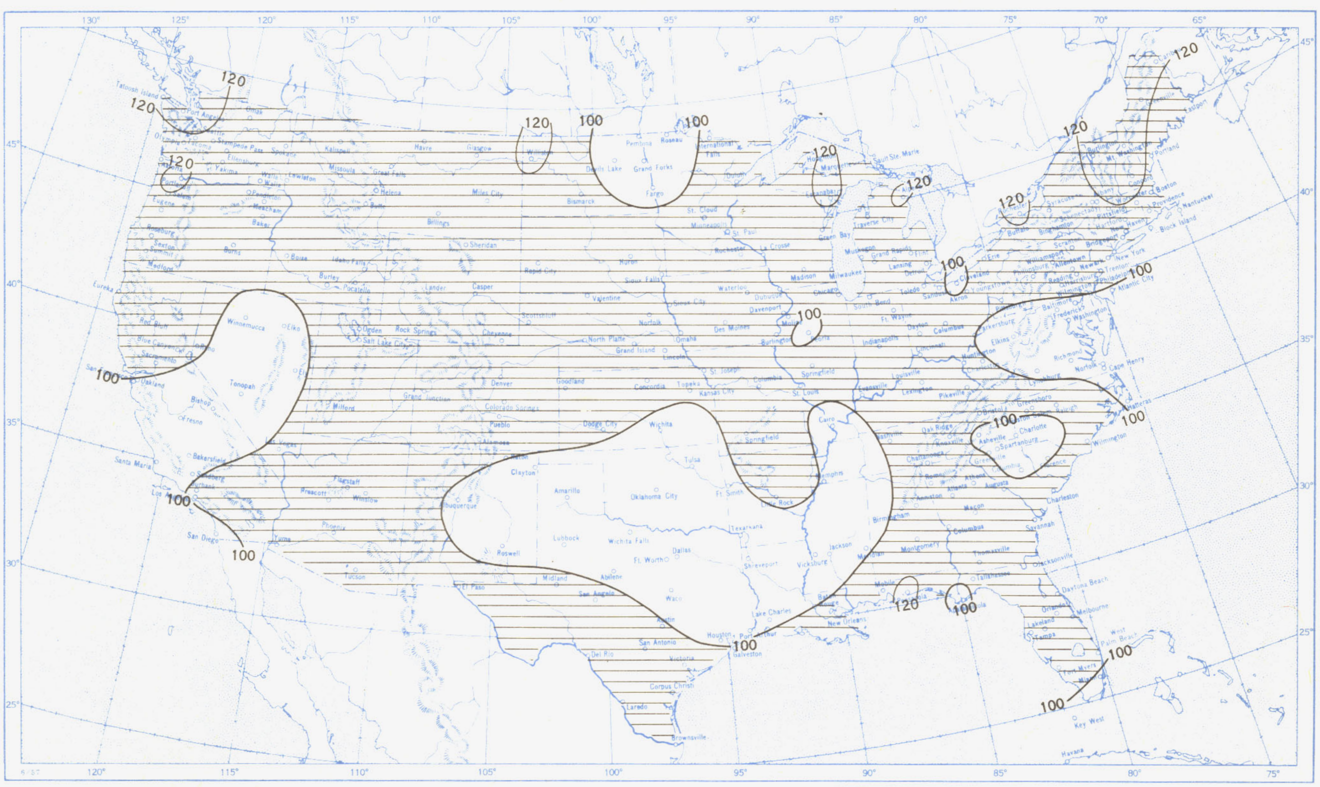


A. In addition to cloudiness, sky cover includes obscuration of the sky by fog, smoke, snow, etc. Chart based on visual observations made hourly at Weather Bureau stations and averaged over the month. B. Computations of normal amount of sky cover are made for stations having at least 10 years of record.

Chart VII. A. Percentage of Possible Sunshine, August 1958.



B. Percentage of Normal Sunshine, August 1958.



A. Computed from total number of hours of observed sunshine in relation to total number of possible hours of sunshine during month. B. Normals are computed for stations having at least 10 years of record.

Chart VIII. Average Daily Values of Solar Radiation, Direct + Diffuse, August 1958. Inset: Percentage of Mean Daily Solar Radiation, August 1958. (Mean based on period 1951-55.)

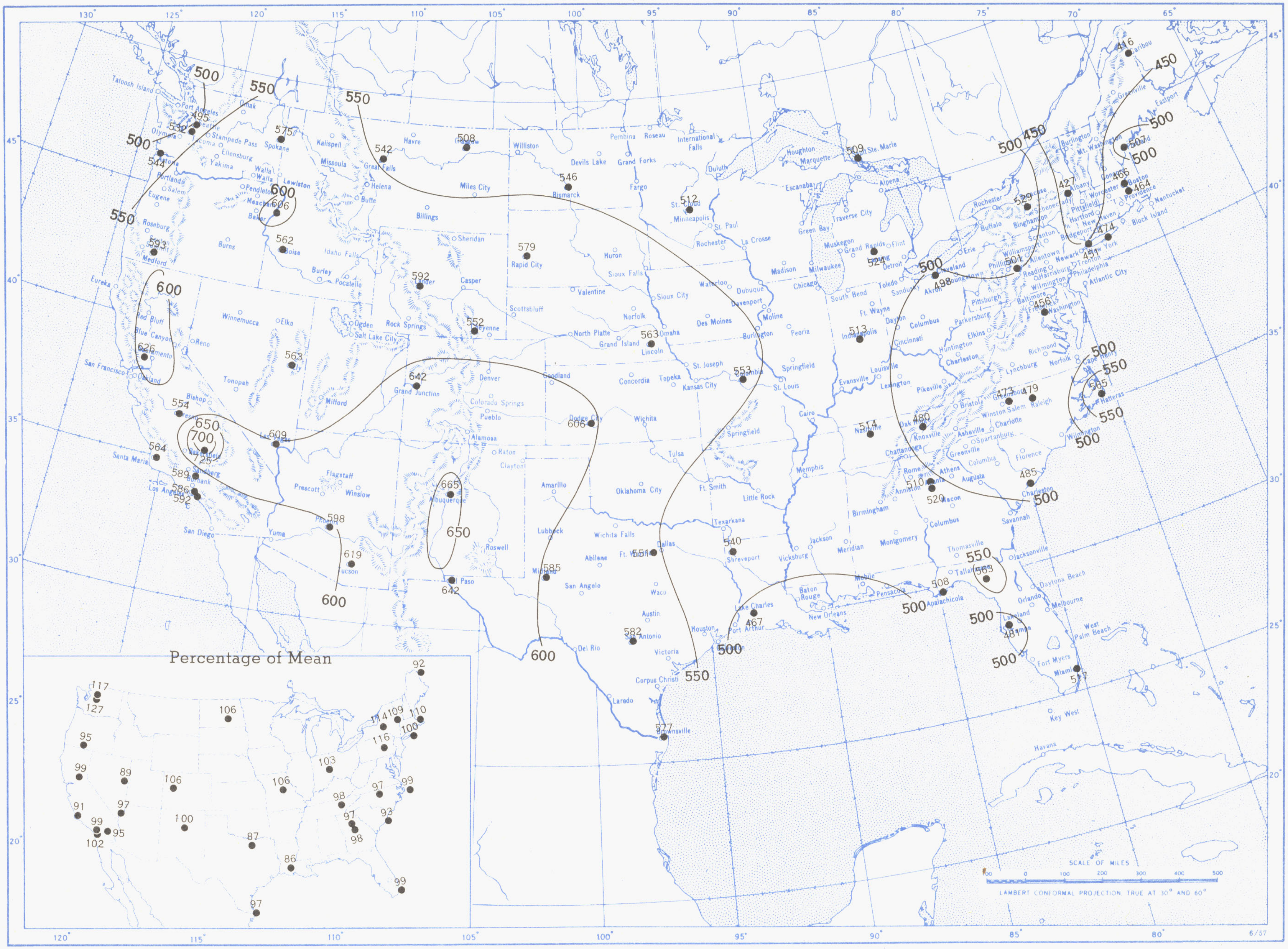
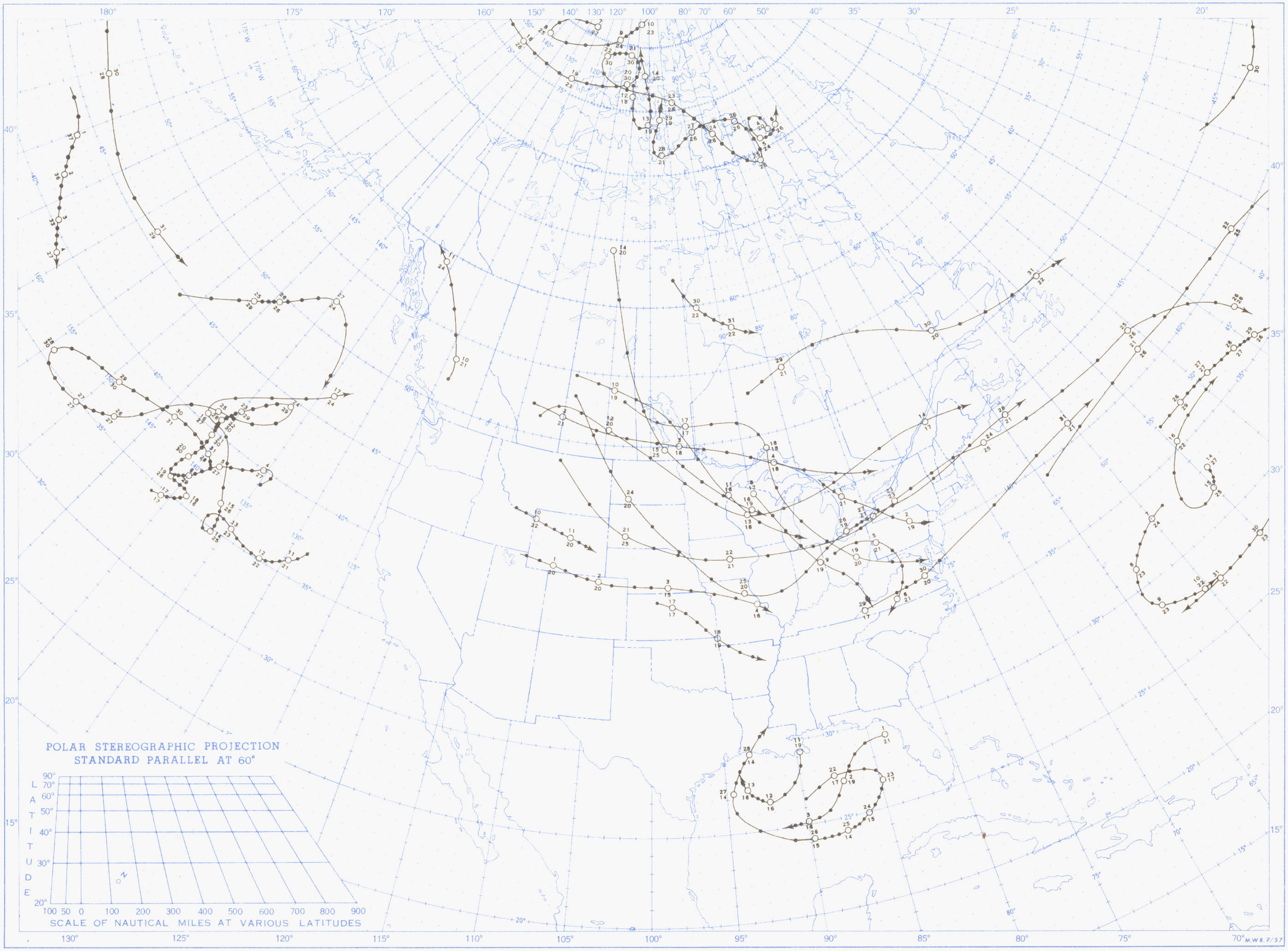


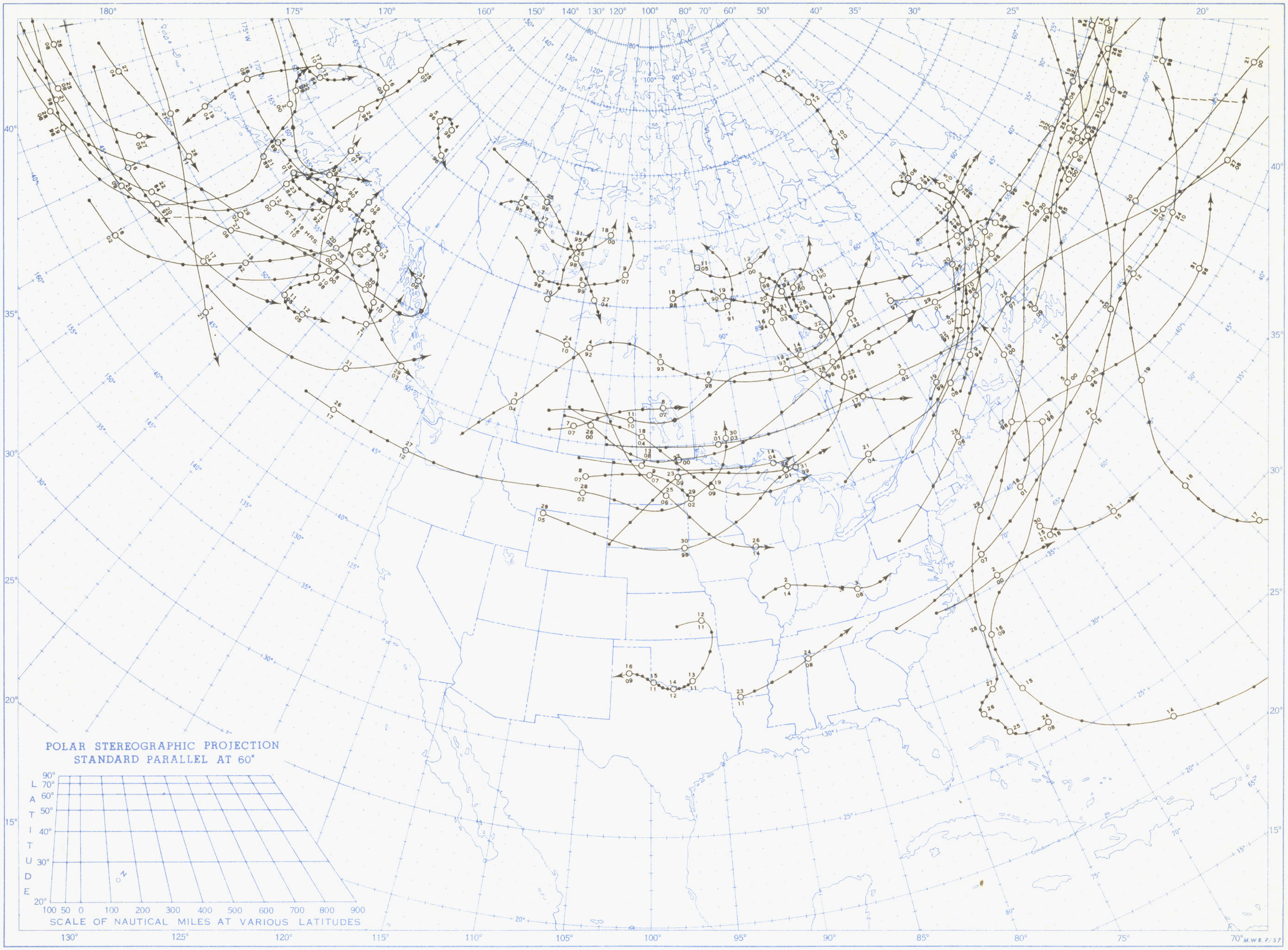
Chart shows mean daily solar radiation, direct + diffuse, received on a horizontal surface in langleys (1 langley = 1 gm. cal. cm. $^{-2}$). Basic data for isolines are shown on chart. Further estimates are obtained from supplementary data for which limits of accuracy are wider than for those data shown. The inset shows the percentage of the mean based on the period 1951-55.

Chart IX. Tracks of Centers of Anticyclones at Sea Level, August 1958.



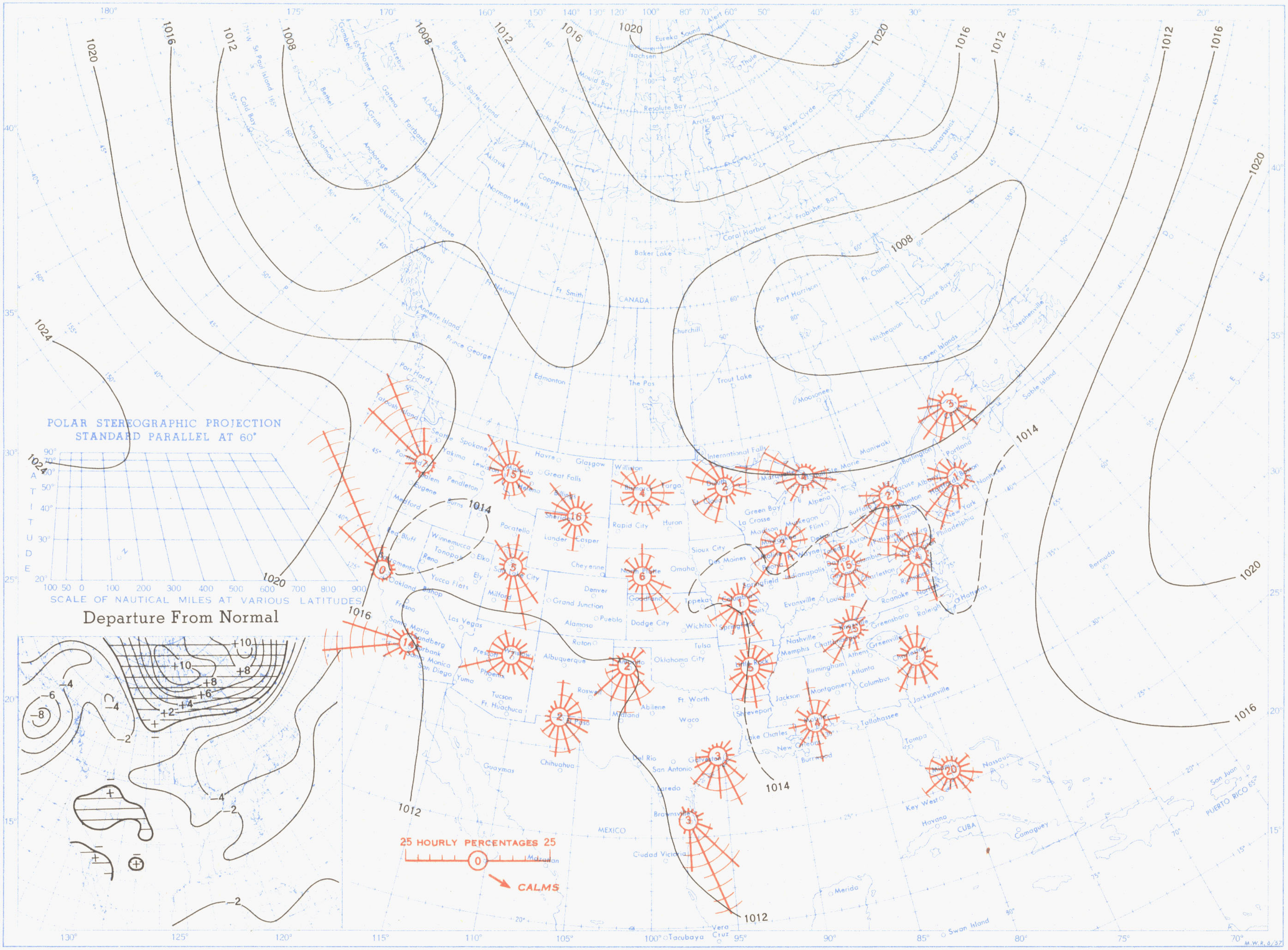
Circle indicates position of center at 7:00 a. m. E. S. T. Figure above circle indicates date, figure below, pressure to nearest millibar. Dots indicate intervening 6-hourly positions. Squares indicate position of stationary center for period shown. Dashed line in track indicates reformation at new position. Only those centers which could be identified for 24 hours or more are included.

Chart X. Tracks of Centers of Cyclones at Sea Level, August 1958.



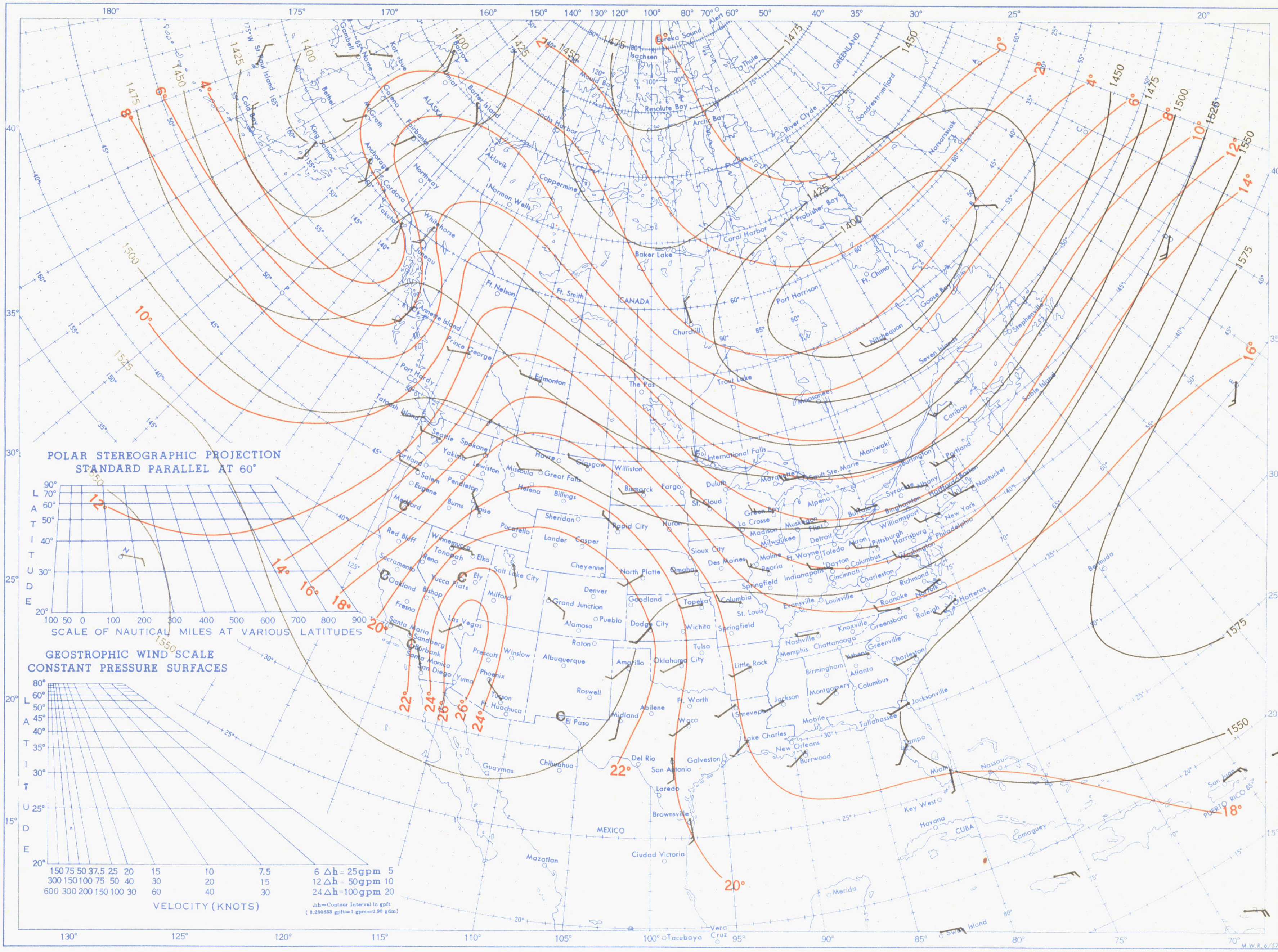
Circle indicates position of center at 7:00 a. m. E. S. T. See Chart IX for explanation of symbols.

Chart XI. Average Sea Level Pressure (mb.) and Surface Windroses, August 1958. Inset: Departure of Average Pressure (mb.) from Normal, August 1958.



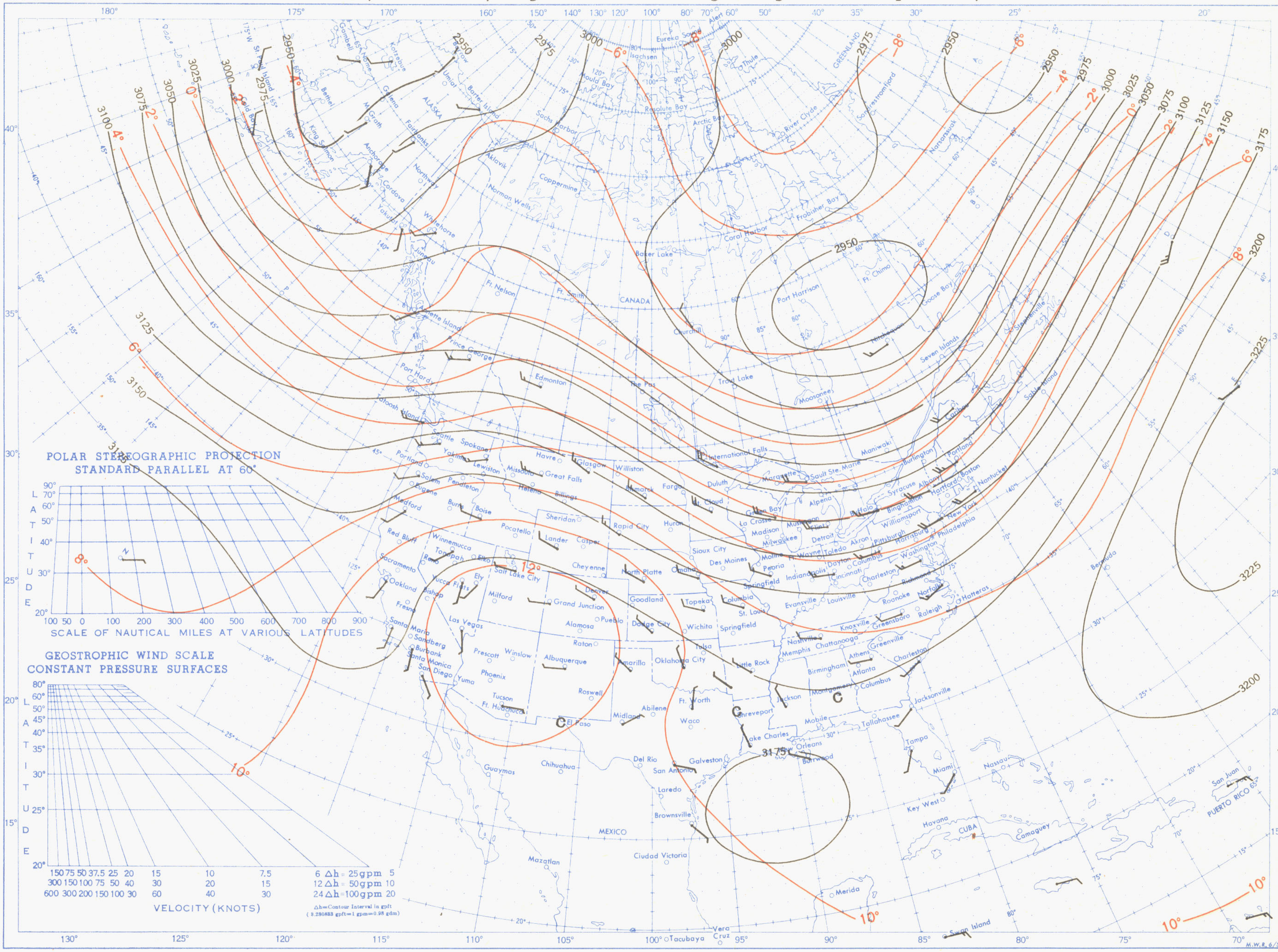
Average sea level pressures are obtained from the averages of the 7:00 a.m. and 7:00 p.m. E.S.T. readings. Windroses show percentage of time wind blew from 16 compass points or was calm during the month. Pressure normals are computed for stations having at least 10 years of record and for 10° intersections in a diamond grid based on readings from the Historical Weather Maps (1899-1939) for the 20 years of most complete data coverage prior to 1940.

Chart XII. 850-mb. Surface, 1200 GMT, August 1958. Average Height and Temperature, and Resultant Winds.



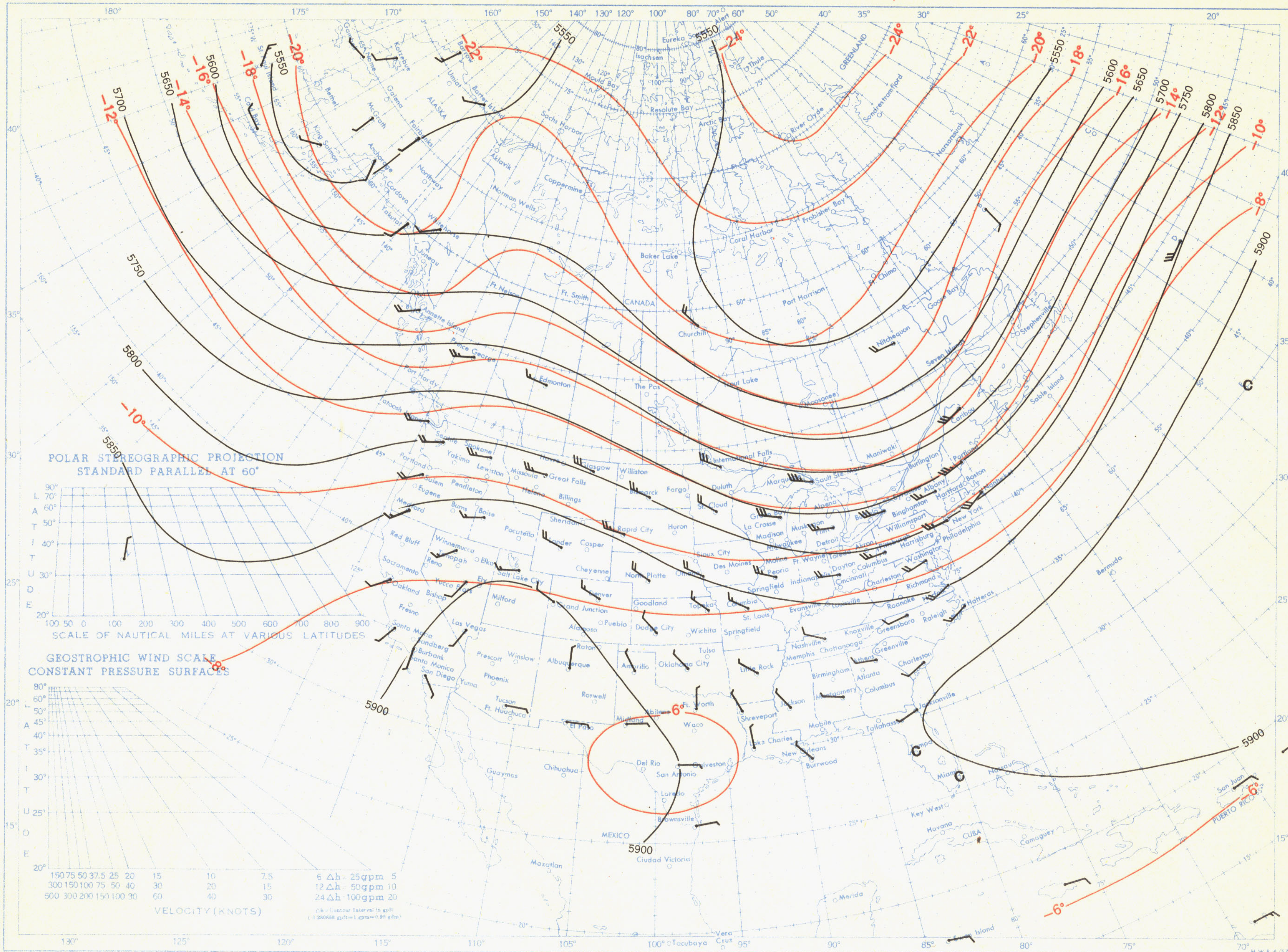
Height in geopotential meters (1 g.p.m. = 0.98 dynamic meters). Temperature in °C. Wind speed in knots; flag represents 50 knots, full feather 10 knots, and half feather 5 knots. All wind data are based on rawin observations.

Chart XIII. 700-mb. Surface, 1200 GMT, August 1958. Average Height and Temperature, and Resultant Winds.



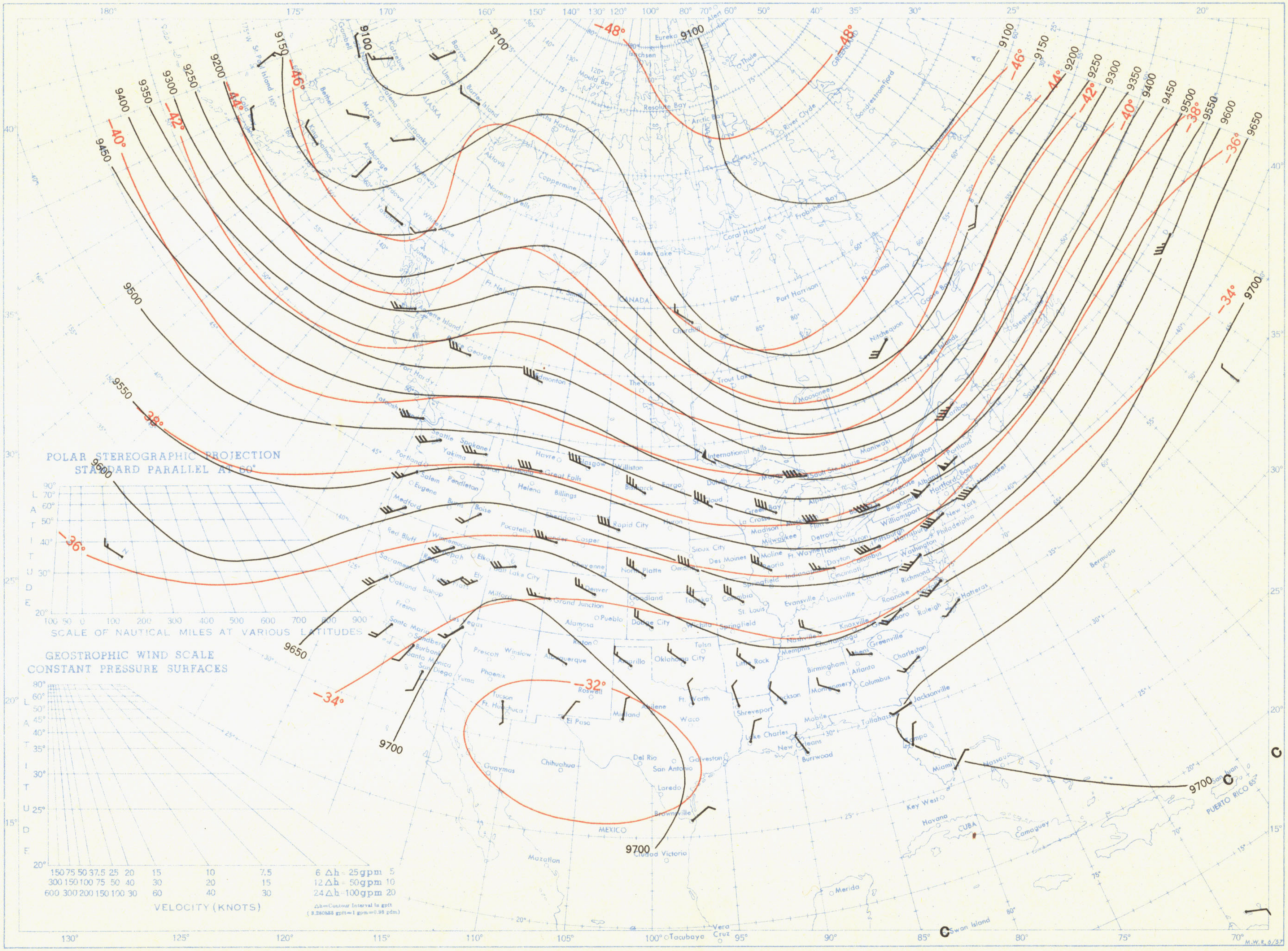
See Chart XII for explanation of map.

Chart XIV. 500-mb. Surface, 1200 GMT, August 1958. Average Height and Temperature, and Resultant Winds.



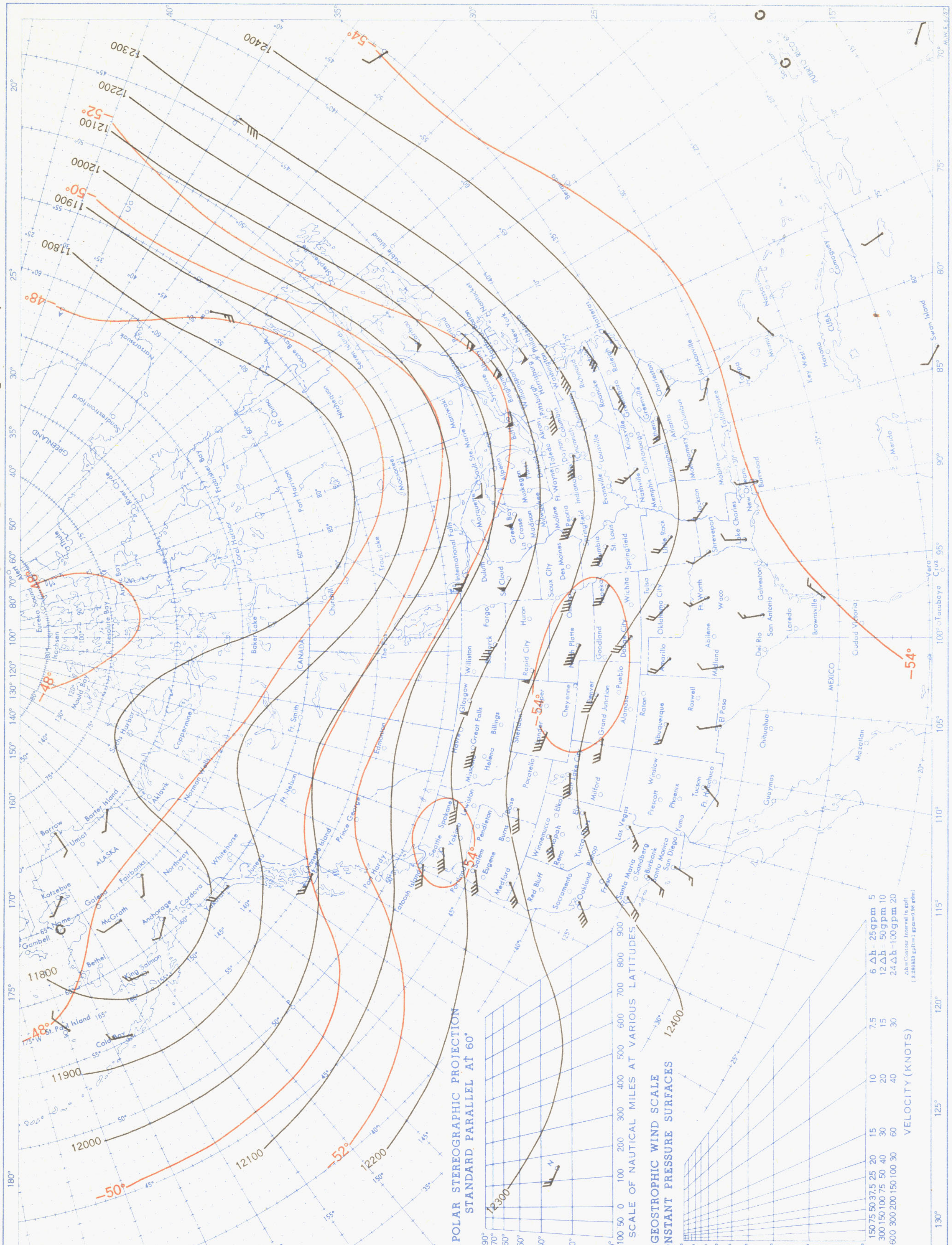
See Chart XII for explanation of map.

Chart XV. 300-mb. Surface, 1200 GMT, August 1958. Average Height and Temperature, and Resultant Winds.



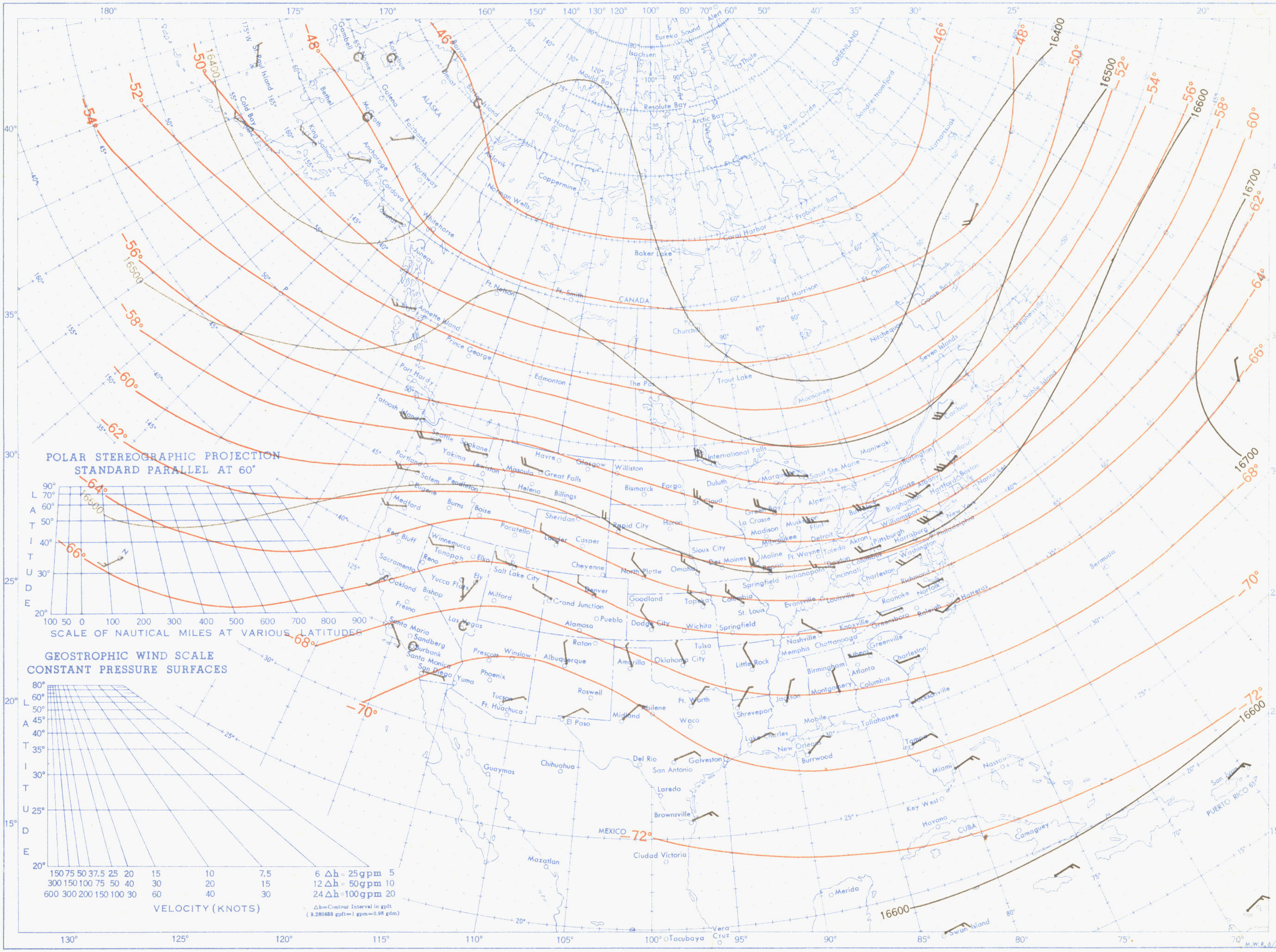
See Chart XII for explanation of map.

Chart XVI. 200-mb. Surface, 1200 GMT, August 1958. Average Height and Temperature, and Resultant Winds.



See Chart XII for explanation of map.

Chart XVII. 100-mb. Surface, 1200 GMT, August 1958. Average Height and Temperature, and Resultant Winds.



See Chart XII for explanation of map.